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Status Report

ENVIRONMENTAL, SAFETY, AND HEALTH ASSESSMENT OF FY93 TASKS IN PROJECT BE1, RESERVOIR CHARACTERIZATION

By

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ENVIRONMENTAL, SAFETY, AND HEALTH ASSESSMENT OF FY93 TASKS IN PROJECT BE1, RESERVOIR CHARACTERIZATION

FOREWORD

This Status Report, prepared in fulfillment of Task 1 of the Annual Research Plan, describes the environmental, safety, and health (ES&H) concerns related to Project BE1 and the actions necessary to address and mitigate those concerns. The objectives of Task 1 are to review the procedures, equipment, and working conditions to ensure compliance with all federal, state, and local regulations, and to ensure that all activities are planned and conducted in a safe and environmentally sound manner. Potential areas of concern in Project BE1 include geological field work, mercury injection porosimetry, and cathodoluminescence. Each of these areas is addressed with a combination of training, standard procedures, and personal protective equipment.

Susan R. Jackson, Senior Geoscientist, BE1 Project Leader — Date: 1/14/93

Michael P. Madden, Manager, Geotechnology — Date: 14 Jan 93

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OBJECTIVE

High priorities on environmental, safety, and health issues are recognized. The objectives of Task 1 of Project BE1 are to review the procedures, equipment, and working conditions to ensure compliance with all federal and local regulations and to ensure that environmental, health, and safety considerations are satisfied.

INTRODUCTION

The scope of work for Project BE1 focuses on two main areas of reservoir characterization: 1) characterization and model construction of two shoreline barrier reservoirs; and 2) the determination and development of reservoir characterization methods and methodology based on those reservoir studies.

The work proposed for FY93 will consist of three main areas: 1) summarize reservoir and production characteristics of the shoreline barrier reservoirs studied; 2) summarize and evaluate the reservoir characterization methods, techniques, and methodology identified and developed in the BE1 project; and 3) conduct technology transfer of the research results. A listing of the scope of the project and the specific tasks planned for FY93 are presented in appendix A.

Potential areas of ES&H for Project BE1 fall into three areas which are outlined in the safety plans presented below. These areas include 1) geological field work, 2) mercury porosimetry, and 3) cathodoluminescence. The mercury porosimeter and the cathodoluminescence apparatus are not yet fully installed, however, we plan to have them operational during FY93. The Project Plan ES&H Checklist (appendix B) summarizes the items that should be considered in the safety plan implementation for each of the three areas of concern listed above.

SAFETY PLAN FOR GEOLOGIC FIELD WORK

Potential Hazards

Geologic field work involves driving and walking to remote places and often strenuous climbing up rock slopes. The major dangers associated with the work are injuries from falling and from falling rocks, cuts and bruises, snake and insect bites, and sun stroke. Most of these dangers can be prevented by proper training and a limited amount of protective gear. The experience and training obtained from the university geological curriculum provides the necessary skills for safe operations in the field.

Corrective Actions

Training that stresses the following points should be sufficient to prevent the majority of mishaps and injuries.

1. Always watch where you step and pay attention to overhanging rocks.
2. Never climb a steep slope when people are directly below you. Hard hats should be worn if there is a possibility of being hit by falling debris.
3. If you dislodge a rock or loose dirt, shout out a warning to those below.
4. In general, avoid placing feet or hands into holes and crevices to avoid surprising snakes or other animals. When climbing up an outcrop, never place your hands above eye level.
5. When you must pass through an area adjoining holes, crevices, or brush piles, make extra noise and throw a few rocks ahead of you to warn animals.
6. Always do field work with a partner. If you must work in separate areas for long periods of time, take walkie talkies so that communication can be maintained.
7. Current training in Adult First Aid and CPR should be maintained
8. A 4-wheel drive vehicle should be used for outcrop locations not along paved roads.
9. Tetanus shots should be current (every 8-10 years).
10. Cellular phones provide instant communication to hospital and helicopter services and should become standard field safety equipment. They have recently become available at affordable costs and can be purchased or rented from car rental agencies.
11. Regular medical check-ups and maintenance of good physical condition.

Gear

1. Protective personal gear should include a hat, sun screen, sturdy boots for climbing, waterproof jacket with hood, sunglasses, and insect repellent, where needed.
2. When drilling core plug rock samples, safety glasses, face shield and gloves are required. Hard hats should be worn when there is potential for head injury.
3. First aid kit with bandages, antiseptic wipes and ointments, instant ice.

A Safety Plan Would Include:

1. Location (distance and time) of nearest telephone
2. Location (distance and time) of nearest hospital
3. Appropriate maps (topographic and road)

SAFETY PLAN FOR MERCURY-INJECTION POROSIMETER

Potential Hazards

Working with the mercury-injection porosimeter involves dealing with vacuum and pressure injection of mercury into small samples. Major dangers associated with the work are a) implosion of the low pressure cell, b) broken seals during the high pressure runs (atmospheric to 60,000 psi), and c) possible mercury contamination of the laboratory. Most of these dangers are minimized by internal fail-safe mechanisms built into the machinery, the small amounts of mercury used, and by wearing a minimal amount of standard protective gear. Further safety evaluation will continue once the unit has been made operational.

Corrective Actions

Training that stresses consistent safe handling of the apparatus and of the mercury contaminated samples would prevent accidents or spillage of mercury. The following points should be stressed:

1. Always check the glass sample holders for mercury before running tests.
2. Always clean the glass sample holders using an approved method after running tests.
3. The contaminated sample holder and rock sample should be flushed with a solvent such as acetone to remove excess mercury. The excess mercury and acetone should be captured in a covered glass container until a sufficient amount is accumulated to clean and reclaim the mercury for further use.
4. The equipment holding the pressure cells (low and high pressure) should be set into shallow trays of non-absorbent materials (e.g.. steel) that can be cleaned after each run. Cleanup of the trays for spilled mercury droplets should be with a unit comprising a flexible vacuum line with a small (glass) nozzle that drops picked up mercury into a storage flask.
5. After a sufficient amount of mercury has been salvaged in the storage flask (about 500 ml) it should be purified and reclaimed for additional usage.
6. All feasible preparation and takedown of cells and samples should be done in a well-ventilated laboratory hood.
7. Because mercury vapors are extremely dangerous, no open flames or heating type instruments should be used in the same room with the porosimeter, when it is actively being used or during clean-up procedures at the end of runs.
8. Disposable rubber lab gloves and any paper towels, etc. used during the cleanup of the machinery, and at the end of runs should be disposed of as hazardous waste, in appropriately marked containers, not in the general trash containers.
9. The low pressure sleeve should be checked for cracks or chips every time it is used. Taping the exterior of the sleeve should prevent scatter of glass if the sleeve should ever implode.
10. Although it is highly unlikely that the high pressure cell would ever explode during a run, the gaskets and threads of the confining jacket should be checked carefully before each run.
11. No one other than trained personnel should be allowed to run the mercury porosimeter.
12. The mercury-contaminated rock samples should be flushed with a solvent (acetone) and the fluid saved in a covered container in the laboratory hood for later reclaiming of mercury. The samples themselves should be stored in the laboratory hood, dry, in another labeled container until a sufficient quantity is accumulated for proper disposal. At that time the rock chips should be properly packaged, labeled "hazardous waste," and the NIPER safety officer notified so as to arrange for disposal.

Gear

1. Protective rubber laboratory gloves should be worn at all times when working with the porosimeter, the cells, oil, or mercury.
2. A spill control kit for mercury should be kept near the required laboratory hood.

3. The vacuum cleanup mechanism including a flexible hose, a small nozzle and a storage flask should be connected by flexible hose to house vacuum, and on a long enough hose to reach all parts of the pososimeter machinery or areas where mercury might be spelled.
4. Face shield or goggles are recommended eye-protection during take-down and cleanup operations in the hood at the end of runs.

A Safety Plan Would Include:

1. Develop a standard operating procedure for the mercury-injection porosimeter.
2. Wearing of protective laboratory gear.
3. Complete cleanup and safe storage of reclaimed mercury in an appropriate covered container in the laboratory hood.
4. Disposal of mercury contaminated rock samples as "hazardous waste". Mercury vapor monitoring must be done for personnel exposed. Those who handle mercury must have appropriate physical exam.
5. Safe cleaning of all glassware required for apparatus.
6. Mercury spill response.

Environmental Compliance

1. Disposal costs for mercury contaminated rock samples.

SAFETY PLAN FOR CATHODOLUMINESCENCE UNIT

Potential Hazards

Working with the cathodoluminescence unit involves manipulation of the electronic console that controls high voltage, and impingement of an electron beam on samples that creates small amounts of gamma ray radiation. A vacuum pump is used to keep the examination chamber at low pressure. The potential for personal injury to the operator is minimal. The electronics parts are self contained and the main concern, as with all electrical equipment, is that the unit is properly grounded. The examination chamber view window is constructed of leaded glass and provided with special sealing gasket that prevent escape of radiation. However, with time small leaks may be detected and must be stopped. Further safety evaluation will continue once the unit has been made operational.

Corrective Actions

Only trained, experienced personnel should be allowed to use the unit. Safe procedure of the cathodoluminescence unit should stress the following points:

1. The vacuum pump should be properly ventilated. If used in a small, confined space this may require ventilating ducting to conduct possible produced fumes or oil mist from the laboratory space.
2. The apparatus should be checked regularly to ensure that the electrical cords are in good repair and that the ground prong of the wall plug is always attached. This is practically ensured due to the "molded" nature of the modern 3-prong wiring.
3. Vacuum Implosion. The standard viewing windows will withstand atmospheric pressure while the chamber is under vacuum. However, the operator should guard against abrupt changes in microscope focusing which might cause an objective to strike and break the window, or scratch it. Good technique to use when focusing is the slide a small piece of paper back and forth between the objective and the window during focusing. The operator can feel when the objective is just touching the window and can raise the objective slightly to insure that there will be clearance.
4. X-rays. An electron beam will generate X-rays and hence precautions are necessary. The intensity and the energy of the X-rays generated will depend to some extent on the target material the beam strikes. The X-rays generated within the chamber by the beam are absorbed within the metal parts of the chamber. The only route of escape is through the window areas. The windows provided are lead-glass to prevent any X-ray leakage and the gasket used for the bottom window is specially molded to absorb X-rays.

   If a viewing window is broken it is mandatory that the replacement be obtained from the manufacturer to assure that a correct window material, configuration, and size is used for continued X-ray safety.
5. The electron gun should not be operated without the gun shield cover in place. Without the cover in place, there is a possible avenue of escape of X-rays through the discharge tube.
6. The instrument should not be operated if any of the mounting screws, e.g., those which hold the gun cover in place, are missing.

Gear

No protective gear is necessary when operating the luminiscope.

A Safety Plan Would Include:

1. All operators should read the operations manual including the section on safety considerations for the cathodoluminsecence apparatus.
2. Check wiring for general condition (fraying, ground) each time the apparatus is used.
3. Regular checks of the glass windows for chips, scratches, or cracks.
4. Bi-annual radiation check with a Geiger counter.
5. Film badge to be worn by operator when apparatus is being used.

APPENDIX A— PROJECT BE1 ANNUAL PLAN

BE1. RESERVOIR ASSESSMENT AND CHARACTERIZATION

BACKGROUND

The National Energy Strategy calls for the reduction of the Nation's vulnerability to future oil market disruptions. One solution outlined is to increase domestic oil production by increasing the economic recovery potential of existing wells through focused R&D programs. In keeping with this directive, the goal of the Department of Energy's Advanced Oil Recovery Program is to maximize the economic producibility of the domestic oil resource through a highly targeted research, development, and demonstration plan. The following three time-specific objectives address this goal: (1) preserve access to reservoirs with high potential that are rapidly approaching their economic limits, in the near-term; (2) develop, test, and transfer the best, currently defined, advanced technologies to operators, in the mid-term; and (3) develop sufficient fundamental understanding to define new recovery techniques for the remaining oil, in the long-term.

The ongoing research program at NIPER incorporates the elements of each of these objectives. The shoreline barrier reservoirs studied are in the top 10 reservoir depositional classes identified in the ORPIP; they are mature fields with large amounts of remaining oil in place, and are undergoing relatively rapid rates of abandonment. The analyses and models developed in the BE1 project have directly benefited the operators of the fields, as well as those companies operating in similar types of reservoirs in the near-term. For example, the results of our work provide the information required to reposition injection and production wells to optimize production and prevent further well abandonment; and to conduct sensitivity studies on the effectiveness of various enhanced oil recovery techniques to improve oil recovery.

Methods and techniques with near to mid-term applications are developed to quantify the effects of heterogeneities and construct accurate reservoir models. Long-term results of the research are the determination of the transferability of reservoir and production characteristics among reservoirs of similar depositional histories. Identification of similar heterogeneities will allow application of similar reservoir management strategies and enhanced oil recovery methods to maximize recovery efficiency.

The research program at NIPER employs an interdisciplinary approach that has focused on the high priority reservoir class of shoreline barrier deposits to: (1) determine the reservoir characteristics and production problems specific to this class of reservoirs; and (2) develop methods to effectively characterize shoreline barrier reservoirs to predict residual oil saturation

(ROS) on interwell scales and improve prediction of the flow patterns of injected and produced fluids.

Two shoreline barrier reservoirs, Patrick Draw field, WY, and Bell Creek field, MT, have been studied to achieve these goals. Models for both reservoirs were constructed through integration and reconciliation of sedimentologic, diagenetic, structural, reservoir fluid and production/injection data. The reservoir characterization methodology and techniques developed during the study of the first reservoir, Bell Creek field, were applied and refined during the study of Patrick Draw field. New methods were also developed during the second study stimulated by the different heterogeneities and reservoir properties encountered in Patrick Draw field, as well as new insights gained from the previous study.

The methodology and techniques developed in the BE1 program are transferable to other reservoir class. These techniques have also been transferred to operators and other organizations through presentations at oil companies and universities, research symposia and conferences, and professional society technical meetings. Cooperation with the operators of Patrick Draw and Bell Creek fields has resulted in a two-way exchange of information that assures that our research program continues to address those issues most important to operators of domestic fields.

In FY93, the research results from work on shoreline barrier reservoirs will be synthesized and the methodologies, techniques, and data developed will be transferred to the oil industry and other organizations via a workshop. An annotated bibliography of shoreline barrier deposits compiled in FY92 will be updated and, along with electronic data files, will provide a useful reference for the geological and production characteristics of this class of reservoirs.

10. A final report on the research findings of the project will be prepared to be included as a chapter in NIPER's Final Technical Report. This report will include: (1) a summary of the reservoir characteristics of shoreline barrier deposits, using Patrick Draw and Bell Creek fields as examples; (2) a summary and analysis of the reservoir characterization methods, techniques and methodology developed in the BE1 program; and (3) an assessment of the areas of research that have the greatest potential to improve recovery from domestic oil resources. The conclusions from the analysis will provide a guide for planning other reservoir studies outside NIPER as well as in the design of Class 1 fluvial-dominated deltaic reservoir studies.

OBJECTIVES

The objectives of this project are (1) to synthesize reservoir and production characteristics of shoreline barrier reservoirs and to determine the degree to which information from one reservoir can be used to maximize oil recovery from other reservoirs deposited in the same depositional environment; and (2) to develop geological and engineering methods to predict mobile oil saturation distribution and quantify reservoir architecture and flow unit geometry for application to targeted infill drilling and EOR.

SCOPE OF WORK

The BE1 base program research has focused on two main areas of reservoir characterization: (1) the reservoir characterization and model construction of two shoreline barrier reservoirs; and (2) the determination and development of reservoir characterization methods and methodology based on those reservoir studies.

The work proposed for FY93 will consist of three main areas: (1) summarize reservoir and production characteristics of the shoreline barrier reservoirs studied; (2) summarize and evaluate the reservoir characterization methods, techniques, and methodology identified and developed in the BE1 project; and (3) conduct technology transfer of the research results.

The detailed examples from NIPER studies of Patrick Draw and Bell Creek fields will be combined with characteristics found in the literature to portray the spectrum of reservoir heterogeneities and characteristics of this important class of reservoirs. Various EOR methods and infill drilling will be evaluated to determine those recovery methods most suitable for shoreline barrier reservoirs.

Technology transfer activities will include a workshop or short course on the characteristics of shoreline barrier reservoirs and selected techniques for characterizing this class of reservoirs. Also, the data files for Patrick Draw field and an annotated bibliography for shoreline barrier formations will be updated and published.

A final report containing a summary and analysis of the research results in the BE1 project will be prepared. The report will include a summary of shoreline barrier reservoir characteristics and an analysis of the reservoir characterization methods, techniques, and methodology developed in the BE1 research program. This analysis will be used to develop the research approach and design of subsequent reservoir studies on Class 1, fluvial-dominated deltaic reservoirs.

Other areas of activities will include an aggressive effort to promote information exchange between the reservoir characterization expertise in BE1 and other projects (internal technology transfer), by providing characterized core samples for use in measurement and flooding experiments. This activity will leverage the utility of research results by allowing the results of one project to be used by other projects and preventing duplication of sample and site characterization in the Base Program projects.

Task 1. Environmental, Safety, and Health (ES&H) Assessment. (Start date: October 1992. Completion Date: October 1992) (Near-Term)

Evaluate the environmental, safety, and health impact of the activities, procedures, and equipment required to conduct the tasks planned for FY93. Propose safe procedures and equipment set-up design if conflicts with NIPER's ES&H policy are identified. After review by the IITRI ES&H manager, a status report on the assessment results will be submitted to the BPO for approval.

Task 2. Summarize reservoir characteristics of shoreline barrier deposits, using Patrick Draw and Bell Creek fields as examples, and evaluate the effectiveness of various recovery methods and engineering practices in this class of reservoirs. (Start Date: October 1992. Completion Date: June 1993.) (Near- to Mid-Term)

Survey the literature for reservoir characteristics, heterogeneities, and controls on production common to shoreline barrier reservoirs. Compare the characteristics identified from the detailed study of Patrick Draw and Bell Creek fields to those reservoirs reported in the literature to (a) define the spectrum of reservoir characteristics found in shoreline barrier deposits, and (b) assess the degree to which the controls on production found in Patrick Draw and Bell Creek can be generalized to other reservoirs. The characteristics identified will be categorized into depospecific, play specific, or unique classes to assess the degree of transferability of reservoir features from one field to another in the same depositional system.

Additional analyses and integration of Patrick Draw and Bell Creek field data will be made where necessary to complete the summary and comparison of reservoir characteristics and the controls on production.

Evaluate the engineering practices and recovery methods used in Patrick Draw and Bell Creek fields to determine the effectiveness and suitability for those characteristics identified in the reservoirs. Survey literature for information to determine the effectiveness of various recovery methods and engineering practices, including enhanced oil recovery (EOR), infill drilling and horizontal wells, in shoreline barrier reservoirs.

Task 3. Summarize and Evaluate the Reservoir Characterization Techniques, Methods and Methodology Developed in the BE1 Project. (Start date: October 1992. Completion date: June 1993.) (Near- to Mid-Term)

Summarize the reservoir characterization data requirements, methods, techniques and methodology identified in the BE1 research program from FY85 through FY93.

Analyze research findings and identify those areas of research that have the greatest potential to maximize the economic producibility of the domestic oil resource in the near-, mid- and long-term. Recommend areas of further research for the Reservoir Assessment and Characterization research program.

Task 4. Promote information exchange between BE1 and other projects by providing characterized cores. (Start date: October 1992. Completion date: June 1993) (Near-Term)

Where needed, assist in the identification, selection, and characterization of outcrop and core samples to be used in other Base Program projects for flooding and imaging experiments.

Task 5. Conduct a Technology Transfer Activity. (Start date: October 1992. Completion date: September 1993) (Near-Term)

Transfer information on reservoir characterization methods and characteristics of shoreline barrier reservoirs to other organizations. Potential users of this information include independent operators, major oil companies, professional societies, government agencies, and universities.

Determine the format of the technology transfer activity. Various formats considered for the technology transfer activity will include a workshop or short course, in conjunction with a professional society meeting.

Prepare presentations and handouts necessary for technology transfer.

Update and publish database and annotated bibliography for shoreline barrier formations.

Task 6. Prepare Final Report. (Start date: March 1993. Completion date: July 1993.) (Near-Term)

Prepare a chapter in the Final Technical Report, this report will include a summary and analysis of the research results in the BE1 project. Emphasis will be on the results obtained in the last 5 years (1988-93), since NIPER-390 addresses 1985 through 1988. The report will include the results of Task 2, a summary of reservoir characteristics of shoreline barrier deposits, using Patrick Draw and Bell Creek fields as examples; and Task 3, a summary and analysis of the reservoir characterization methods, techniques and methodology developed and identified in the BE1 research program. An assessment of the areas of research that have the greatest potential to improve recovery from domestic oil resources will also be included. The analysis and conclusions contained in this report will be used to develop the research approach and design of subsequent reservoir studies on Class 1, fluvial-dominated deltaic reservoirs.

BENEFITS AND TECHNOLOGY TRANSFER

Technology transfer will be achieved through publications, presentations, organization of a technology transfer activity, and direct interaction with operators and the Naval Petroleum Reserves. The specific benefits will be as follows:

- Reservoir models and reservoir characterization methodologies developed will allow operators of Patrick Draw and similar fields to improve reservoir management and optimize oil recovery operations. Near-term application.

• The summary of reservoir characteristics of shoreline barrier deposits will identify the reservoir features (and scales) that can be expected to control production in shoreline barrier reservoirs. This information will enable reservoir management decisions on the most effective engineering and enhanced oil recovery methods to maximize recovery efficiency. Near-term application.

• The organization of a technology transfer activity will assure direct communication of the research results to operators and researchers that can benefit from them. This activity will also provide two-way communication so that NIPER's research program continues to address those issues most important to the oil industry. Near-term application.

• Information exchange between the reservoir characterization expertise in BE1 and other projects within NIPER will leverage the utility of research results by allowing the results of one project to be utilized by other projects and prevent duplication of efforts among the base program projects. Near-term application.

• The identification of research areas that have the greatest potential to maximize the economic producibility of the domestic oil resource will provide guidance for further research. Near- to mid-term application.

• Application of methodology developed as well as expertise in depositional environments and formations producing in the Naval Petroleum Reserves will assist in reservoir management decisions, selection and design of optimum recovery processes. Near-term application

DELIVERABLES

Nov 92	Status report on environmental, safety, and health assessment.
Jun 93	Updated database on Patrick Draw field and annotated bibliography on shoreline barrier deposits.
Aug 93	A chapter in the NIPER Final Technical Report summarizing the accomplishments of project BE1 with emphasis on the last 5 years.
Aug 93	Status report on research plan for characterizing Class 1, fluvial-dominated deltaic reservoirs.
Sep 93	Technology transfer activity.

APPENDIX B—PROJECT PLAN ES&H CHECKLIST

For Geological Field Work

[ ] Location (distance and time) of nearest telephone
[ ] Location (distance and time) of nearest hospital
[ ] Appropriate maps (topographic and road)
[ ] Hard hats worn if chance of head injury

For Mercury Porosimeter Operation

[ ] Develop a standard operating procedure for the mercury-injection porosimeter.
[ ] Wearing of protective laboratory gear.
[ ] Complete cleanup and safe storage of reclaimed mercury in an appropriate covered container in the laboratory hood.
[ ] Disposal of mercury contaminated rock samples as "hazardous waste".
[ ] Safe cleaning of all glassware required for apparatus.
[ ]Mercury spill response.

For Cathodoluminescence Instrument Operation

[ ] All operators should read the operations manual including the section on safety considerations for the cathodoluminsecence apparatus.
[ ] Check wiring for general condition (fraying, ground) each time the apparatus is used.
[ ] Regular checks of the glass windows for chips, scratches, or cracks.
[ ] Bi-annual radiation check with a Geiger counter.
[ ] Film badge to be worn during operation of equipment.